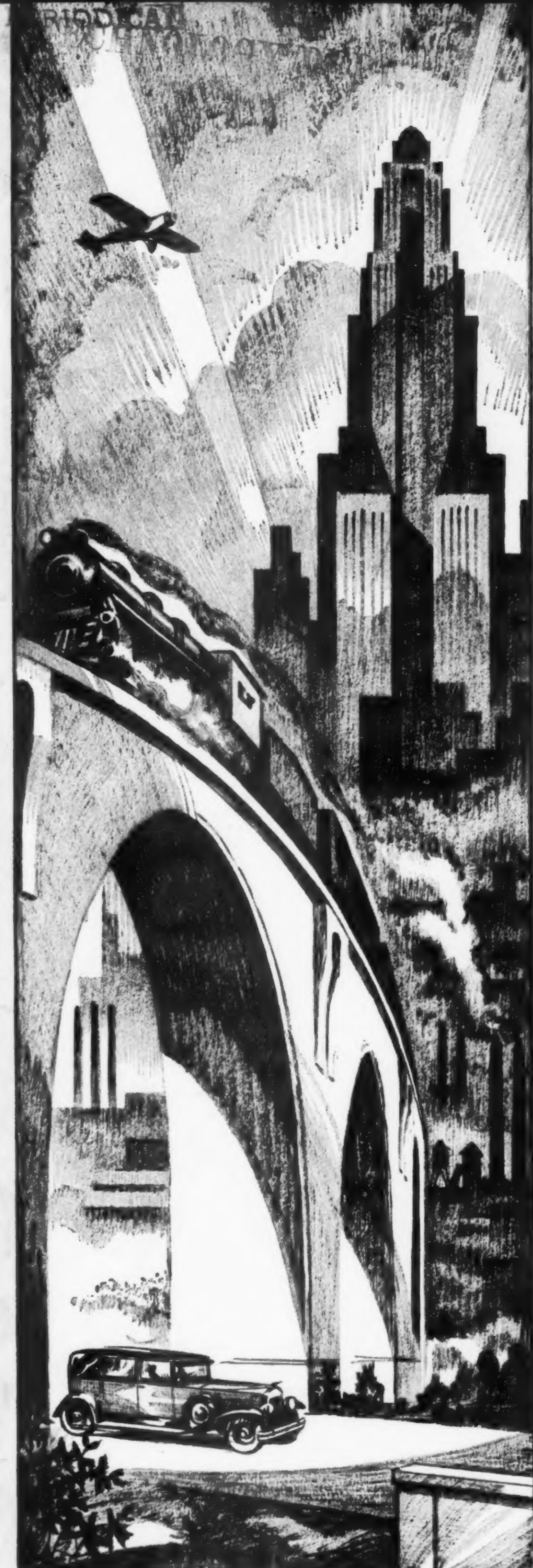
The CRUSHED STONE JOURNAL



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Crushed and Broken Stone in 1937

July-August · 1938

Official Publication
NATIONAL CRUSHED STONE ASSOCIATION

Technical Publications

of the

National Crushed Stone Association, Inc.

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Single copies of the above bulletins are available upon request.

Manual of Uniform Cost Accounting Principles and Procedure for the Crushed Stone Industry ($2.00 per copy)

The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

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THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

Vol. XIII No. 4 JULY-AUGUST, 1938

Directors Again Select Cincinnati for Annual Convention

IN ACCORD with action taken at the mid-year meeting of the Board of Directors the twenty-second annual convention of the National Crushed Stone Association will be held at the Netherland Plaza Hotel, Cincinnati, Ohio, on January 30, 31 and February 1, 1939. The decision to return to Cincinnati for the third consecutive year was reached only after the most careful consideration and with the firm belief, in view of certain exceptional circumstances which developed during the early part of the year in connection with the consideration of possible convention locations, that the best interests of the Association and its members, both active and associate, would thus be served.

In selecting a location for the convention next January those charged with this responsibility encountered more than the usual difficulties. In the first place, notwithstanding the fact that a gradual improvement in business conditions is generally anticipated for the current year, it was not felt that such improvement would be sufficiently advanced by the end of next January to justify the holding of the annual convention at a location too far removed from the center of the industry if our expectations for a good attendance were to be realized. Past experience has indicated a willingness on the part of convention delegates to travel greater distances and to devote more time to convention attendance when business conditions are favorable than when otherwise is the case. In considering possible locations for the meeting in January, therefore, it was considered essential in order to maintain a high attendance to locate the convention as nearly central to the industry as circumstances permitted.

A further important consideration was the popularity among exhibitors of the plan in effect last year of holding our convention at the same hotel as that of the National Sand and Gravel Association, but during a successive week, thus effecting real economy for the exhibitors participating in both expositions.

In view of these specific requirements and keeping in mind the rather exacting convention facilities needed to properly house our annual meeting, a preliminary survey of possible locations seemed to limit our choice to either the Palmer House in Chicago or the William Penn in Pittsburgh. Upon inquiry of each of these hotels to learn if they had open dates in January which would be acceptable to us, to our amazement and with some degree of consternation we learned that neither could accommodate us at the time desired. The situation thus created was obviously serious, indicating the strong possibility that if we too long delayed in reaching a decision our difficulties in obtaining a suitable location would become even more pronounced.

Accordingly, at a meeting of the Executive Committee held in Washington on April 6, the matter was presented in full detail with the result that it was

***Upper right and left*— Among those who enjoyed the excellent golf facilities at French Lick.**

***Upper and lower center*— President T. I. Weston addresses the meeting.**

***Bottom*— Among the ladies who were luncheon guests of the Association.**

decided, subject to the approval of the Board of Directors, to hold the next annual convention at the Netherland Plaza Hotel in Cincinnati. The Hotel agreed to hold open for us the dates desired until the Board at its mid-year meeting could either reject or approve the action of the Executive Committee.

As the constitution of the Association specifically invests in the Board of Directors the responsibility to select the time and place of the annual convention, it is necessarily embarrassing to the Executive Committee, even under emergency circumstances, to act for the Board in this important matter. The difficulty which we experienced in obtaining open dates at acceptable hotels for our next annual meeting indicates a definite trend among trade associations today to determine from one to two years in advance upon the date and location of their annual conventions. This results in the strong possibility, if we continue to delay our decision until the mid-year meeting of the Board, that hotels which might receive our favorable consideration will be eliminated because of previous commitments. With this situation in mind there was scheduled on the agenda for consideration at French Lick the selection of the time and place of the annual convention to be held in January, 1940. Invitations were personally presented by the following:

Charles R. Wilson, Sales Manager, William Penn Hotel, Pittsburgh, Pa.

Carl Roessler, Manager, Hotel Jefferson, St. Louis, Mo.

C. K. Dwinell, Manager, French Lick Springs Hotel, French Lick, Ind.

Royal W. Ryan, Sales Manager, Netherland Plaza Hotel, Cincinnati, O.

Frank C. Drane, Convention Manager, Jung Hotel, New Orleans, who had previously indicated his intention of presenting his invitation in person was prevented from attending because of a sudden illness in his family.

After an extended discussion, following the presentation of these invitations, the opinion developed that it would be unwise to make a decision as much as a year and a half in advance, although it was fully recognized that to delay action until the mid-year meeting of the Board was likely to narrow the field of selection to an undesirable degree. To meet this difficulty the Board instructed the Executive Committee to make a careful study of possible locations for the annual meeting in 1940 without taking any action whatever which would bind the Board and to submit a recommendation at the meeting of the Board to be held next January as to a date and place for the 1940 convention.

Little need be said concerning the excellent advantages enjoyed by Cincinnati and the Netherland Plaza Hotel as a meeting place for our annual convention. From the point of view of location, Cincinnati is ideally situated, being but an overnight ride for a vast majority of the industry. Its easy accessibility makes possible economies in both time and money for those attending the meeting.

The convention facilities of the Netherland Plaza are admirably suited to our requirements. Practically all convention activities can be concentrated on one floor which provides adequate space for the Manufacturers' Division Exposition, Registration, Group Meetings, luncheons and the general sessions. From past experience we can confidently rely upon the full cooperation of the management and know that everything possible will be done for the pleasure and comfort of those in attendance.

Developments during the past year provide an abundance of material from which we are confident that a most enjoyable and instructive program can be developed. Activities in this regard have already been undertaken and we are sure that every crushed stone producer will find the trip to Cincinnati next January decidedly worth his while. Make your plans now to be with us at the Netherland Plaza Hotel on January 30, 31 and February 1, 1939.

It was largely in response to the pressing and cordial invitation of Messrs. Krause and Kelb that the Excutive Committee decided to hold the mid-year meeting this year at French Lick and they must share our gratification in the knowledge that there were present twenty-one members of the Board and eleven guests. Following is a list of those who were in attendance:

MEMBERS OF THE BOARD

T. I. Weston	M. S. Lambert
J. R. Boyd	John Prince
F. O. Earnshaw	H. E. Rainer
A. T. Goldbeck	Russell Rarey
O. M. Graves	J. A. Rigg
A. A. Hall	H. E. Rodes
R. P. Immel	Dan Sanborn
H. A. Johann	James Savage
N. E. Kelb	Stirling Tomkins
E. J. Krause	R. S. Wilson

A. L. Worthen

GUESTS

W. A. Crary, Jr., W. A. Crary & Sons, Columbia, S. C.

J. L. Fay, Moulding-Brownell Corp., Chicago, Ill.

S. C. Hadden, Indiana Mineral Aggregates Ass'n, Indianapolis, Ind.

Horace C. Krause, Columbia Quarry Co., St. Louis, Mo.

Ralph E. McLean, East St. Louis Stone Co., East St. Louis, Ill.

R. W. Meisinger, HyRock Products Co., Evansville, Ind.

S. A. Phillips, Pit and Quarry, Chicago, Ill.

George Rippetoe, Anna Quarries Co., Anna, Ill.

N. C. Rockwood, Rock Products, Chicago, Ill.

E. D. VanCleave, Ohio and Indiana Stone Co., Greencastle, Ind.

F. O. Wyse, Bucyrus-Erie Co., South Milwaukee, Wis.

We noted with pleasure that John Prince, The Stewart Sand and Material Company, Kansas City, Mo., and R. S. Wilson, Big Rock Stone and Material Company, Little Rock, Arkansas, found it possible to be present as we have not enjoyed the pleasure of their company at a mid-year meeting of the Board for sometime.

The ladies were well represented at French Lick as many of the members were accompanied by their wives and we are glad to observe that the practice of bringing the ladies to the mid-year meeting of the Board continues to grow in popularity. They are always most cordially welcome and we trust they will be present in ever increasing numbers during the years ahead.

Mrs. Krause very kindly undertook to handle the arrangements in behalf of the ladies' entertainment and we understand they had a thoroughly enjoyable luncheon on the day of the Board meeting as guests of the Association.

Mr. and Mrs. Fred O. Earnshaw received congratulations from all present when it was learned that the day of the meeting coincided with their fortieth wedding anniversary. As we happen to know that a celebration was being planned for them at home, we feel especially grateful for the personal sacrifice they made in attending the meeting. Incidentally, speaking of wedding anniversaries, Mr. H. A. Johann, Chairman of our Manufacturers' Division and his wife, both of whom were present at the French Lick meeting, celebrated their fiftieth wedding anniversary during the early part of the year and we take this opportunity of extending our most hearty congratulations.

After selecting the time and place of the next annual convention and the general discussion of policy concerning this matter which then developed, the Board received detailed reports covering the activities of the first half of the year from the Engineering Director and the Administrative Director. Mr. Goldbeck added much to the interest of his discussion by comprehensively illustrating it with lantern slides of laboratory equipment and the results from a number of our more important laboratory investigations. The discussion which followed indicated a keen interest in the work of the Bureau of Engineering and the Research Laboratory. No attempt will be made at this time to give the details of his presentation as he will present a complete report covering the activities of the Bureau of Engineering for the current year at the next annual convention.

Administrative Director Boyd devoted himself largely to developments in the field of Federal legislation during the first half of the year and concluded with a brief analysis of the Association's financial condition. With regard to the latter he stated that Association finances were in a satisfactory condition and should continue so throughout the remainder of the year. Details concerning the Administrative Director's report will be omitted at this time because much of this material has been covered in letters to the membership and the activities of the entire year will be reviewed at the time of the annual meeting.

Following the reports of the officers, Chairman Weston then asked Mr. Graves to speak on "The Dust Control Problem in New York." Mr. Graves explained the New York law regarding silicosis exposure and dust control methods. The strong possibility that other States will follow New York in passing similar legislation made this subject of particular interest. Mr. Graves announced that the New York Department of Labor requested the National Crushed Stone Association and the New York State Crushed Stone Association to name one representative each to sit on a committee to consider a code for the control of silica dust in stone crushing and that Mr. F. J. Buffington of the New York Trap Rock Corporation had been named to represent the National Association, while Mr. R. R. Litehiser, newly appointed Engineering Director of the New York Association, had been named to represent that group. The Board by appropriate resolution instructed the Administrative Director to express to the New York Department of Labor its appreciation for the courtesy

extended the Association in affording us the opportunity to have representation on the committee.

Governmental policy in the administration of Sec. 7 of the 1938 Agricultural Conservation Program bulletin was discussed by Mr. Rarey. He pointed out that the committee of which he was Chairman had drafted and submitted to the Agricultural Adjustment Administration a statement expressing the viewpoint of the Association as to the administration of Sec. 7 and that after reviewing recent invitations to bid put out under the authority of Sec. 7 by the AAA it was his belief that the Administration is following our desires as expressed in the committee's statement.

The question of government competition with the crushed stone industry through WPA was brought to the attention of the Board by E. J. Krause. This subject was discussed by many of the other members. Several members suggested that the best approach in seeking an end to such competition is to register complaint with local WPA administrators, as it was generally agreed when WPA funds are used to operate quarries in competition with an established plant, the local authorities are acting contrary to Federal policy in this regard.

It will be recalled that at the time of our St. Louis convention in 1936, Col. Lawrence Westbrook outlined the Federal policy for us governing such situations and it seems appropriate in view of the continuing interest in this subject to again bring to your attention his observations which we quote as follows:

"Likewise, when you hear that the Works Progress Administration is operating a gravel pit, or a stone quarry, please remember that such operation is actually being carried on under some political subdivision of your state, and not by the Works Progress Administration. Of course, we furnish the money, and we approve general terms and conditions under which this money shall be spent, but the responsibility lies directly upon your local governing unit. In some instances, I am informed that Works Progress money has been used to equip plants for the production and fabrication of materials, and I can readily understand that the setting up of these new plants in competition with private plants would be seriously resented by the owners of the private plants. I think these instances are comparatively few, and I want you to know that this Administration is opposed to such practices. Of course, where local governments want to fabricate their own materials, and in some instances I am sure they have to do this in order to be able to accomplish the project at all, we can interpose no objection so long as they use relief labor, and so long as they do not use Federal funds to purchase plant equipment which will be used on projects other than those financed under our program.

"The real recourse of private producers of building material, however, is with the local governmental units, and with our local officials. We are compelled to decentralize authority and responsibility to the maximum degree, and our local people have the broadest discretion that we can give them under our interpretation of the law and of the intent of Congress. I should think that this decentralization would be gratifying to you. It is much easier for you to deal with people in your community whom you know, than to be compelled to negotiate with some person in Washington who not only does not know you, but who is entirely unfamiliar with local conditions."

After the conclusion of the business session, the three following moving pictures were shown:

Frontiers of the Future
Stop Silicosis
America Marching On

These films seemed to prove most interesting and enjoyable to those present.

Federal Highway Funds Withheld From Massachusetts

THE Department of Agriculture has announced its finding that Massachusetts has diverted State motor vehicle revenues to other than highway purposes in such manner as to make necessary the withholding of $472,862 of the Federal-aid apportionment of $3,171,423 for the fiscal year ending June 30, 1938.

This action is made mandatory by the Hayden-Cartwright Act of 1934 which requires that Federal-aid funds be withheld from any State using the proceeds of State motor-vehicle registration fees, gasoline taxes and other special taxes on motor-vehicle owners and operators for other than highway purposes in an amount greater than was being so used prior to June 18, 1934. The amount to be withheld may not exceed one-third of the apportionment for any fiscal year.

Arthur Sherman Lane

IT IS with deep regret that we announce the death of Arthur S. Lane, Vice President and former Treasurer of John S. Lane and Son, Inc., of Meriden, Connecticut, which took place on Sunday, July 17, 1938. Mr. Lane had been in failing health since suffering a heart attack last December and during the six weeks immediately preceding his demise was confined to his home. His loss will be keenly felt among his many friends in the crushed stone industry and to his family and business associates we extend our deep sympathy in their bereavement.

Funeral services were held from his residence, 72 Colony Street, Meriden, Connecticut. The Association was represented by its Administrative Director and those present from the industry in New England included A. L. Worthen, past president of the Association, Wm. E. Hilliard, Treasurer, both of the New Haven Trap Rock Company; Leanardo Suzio of the L. Suzio Trap Rock Co., Meriden; and C. H. Bennett, Manager of the Southern New England Crushed Stone Association.

ARTHUR SHERMAN LANE
1864-1938

For many years Mr. Lane had been actively identified with the affairs of the National Crushed Stone Association, his company first becoming an active member in November, 1925. It was at this time, it will be remembered, that Otho M. Graves, then President of the Association, was conducting an intensive campaign to obtain adequate funds for the proper conduct of the then recently established Bureau of Engineering and Mr. Lane's decision at that time to join with others in the industry to advance the common good typified a characteristic which endured throughout his entire life.

Mr. Lane was elected to the Board of Directors of the Association at the Detroit convention in January, 1927, and at the Cleveland convention in 1929 he was made Regional Vice President for the Eastern Region which office he held until the time of his death. He was perhaps best known to the general membership for his services as a presiding officer at many of our annual conventions, a responsibility which he always cheerfully and effectively discharged.

For over a decade our organization has enjoyed his constant and helpful support. His loss to the Association and to the industry in which he so ably pioneered will be keenly felt. Mr. Lane first entered the business world at the age of 16 years, obtaining employment as freight agent of the Housatonic Railroad at West Stockbridge, Mass. In 1881 he became freight cashier for the New York, New Haven & Hartford Railroad at New York City. After ten years in that position he became a partner with his father in the crushed stone business under the firm name of John S. Lane and Son in Meriden, Connecticut.

In 1902 the Lane Construction Company was formed to take over the road building part of the business, and Mr. Lane was made treasurer of the corporation.

In 1904 the corporation of John S. Lane & Son, Inc., was formed to take over the remaining business of the old firm and Mr. Lane was elected its treasurer.

Mr. Lane continued as treasurer and director of both companies until 1937 when, because of failing health, he relinquished the duties of those offices and became vice president.

Mr. Lane also had a distinguished career in the civic affairs of Meriden, serving on the Board of Aldermen, the Board of Apportionment and Taxation, and in many other capacities.

In religious affairs he likewise took an active part as a member of the First Congregational Church. He was interested in the Y. M. C. A. and was a large donor to all charitable organizations of Meriden.

Mr. Lane is survived by his wife and son, two sisters, two brothers, four grandchildren and a number of nieces and nephews.

The Relation Between Los Angeles Abrasion Test Results and the Service Records of Coarse Aggregates[1]

By D. O. WOOLF

Associate Materials Engineer,
U. S. Bureau of Public Roads

SYNOPSIS: Because all States do not have the same range in quality of coarse aggregates, and one State with an abundance of hard rock will consider certain test values for quality as necessary which could not be used by other States, it must be emphasized that recommendations are subject to change with local conditions. In general, however, it appears that there is a definite relation between the loss in the Los Angeles test and the service record of materials used in concrete, bituminous construction and surface treatment. On the basis of the data available, the following percentages of wear appear to be suitable for use in specifications to control the quality of coarse aggregates: Concrete, 50 per cent; Bituminous surfacing, 40 per cent; Surface treatment, 40 per cent.

Definite correlations between the loss in the Los Angeles test and the strength of concrete are found; the lower the percentage of wear the higher the concrete strength. Definite correlations are also found with the results of a circular track roller test and a test for soft or friable pieces. It appears that the Los Angeles test gives accurate indication of the quality of the material under test, and that its use in specifications controlling the acceptance of coarse aggregate is warranted.

THE proposal to adopt the Los Angeles abrasion test as a substitute for the present standard methods of determining the resistance to abrasion or impact of coarse aggregate has raised the question as to what relations exist between the results of this test and service behavior. In 1935 the Committee on Correlation of Research in Mineral Aggregates of the Highway Research Board recommended that a study of this feature be made and a request for information was sent to all highway engineering authorities. Considerable information was collected in 1935 and 1936 by the Board, and this was supplemented by additional data secured by the Bureau of Public Roads in 1937.

For purposes of discussion the information which has been secured will be classified under two heads; first, that showing a direct comparison between the Los Angeles test result and the service record of the material, and second, that comparing the Los Angeles test result with strength tests of concrete or with wear tests of aggregate which simulate the action of traffic. In presenting the data on service behavior effort has been made to present the information from different sources in similar terms in order to permit of ready comparison. Also to insure that no error of interpretation has been made, laboratory reference numbers are given, where available, to designate the particular materials under consideration so as to permit ready checking of the service records reported here by the authorities from whom the data were obtained.

Comparisons with Service Records

Data comparing the Los Angeles abrasion test results with service records have been obtained from eight State highway departments and a highway board in Australia. In general, the data as presented in Tables 1 to 9 show the type of material, the Los Angeles abrasion test result, the service record of the material when used in concrete, bituminous pavement, or surface treatment construction, and a laboratory number designating the material. The letter S indicates that the results in service have, in general, been satisfactory, the letter Q that the exact rating is in question and the letter U that generally unsatisfactory results have been obtained. In a number of cases several samples of the same material are shown in the original data from which these tables were compiled. In such cases the value shown in the table is the average of all the values reported. Also the values given as the Los Angeles test result are generally averages of the two gradings permitted in the test method.

Table 1 presents service records compiled by the Florida State Roads Department. With only two exceptions all rock and blast furnace slag with Los Angeles test results of less than 40 per cent are classed as being satisfactory for use in concrete, bituminous construction and surface treatment. The two exceptions are a slag with a Los Angeles loss of 28.8 per cent which is considered unsuitable for use in surface treatment, and a limestone with a Los Angeles loss of 38.2 and having a rough open texture which is considered questionable or unsuitable for

[1] Reprinted from Proceedings of the Seventeenth Annual Meeting of the Highway Research Board, December, 1937.

all three types of construction. Gravel from three sources with Los Angeles losses from 41 to 48 per cent are classed as satisfactory for use in concrete and bituminous construction, but as questionable for use in surface treatment.

TABLE 1

COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY FLORIDA STATE ROAD DEPARTMENT

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Concrete	Bituminous construction	Surface treatment
54673	Rock	Dolomite	14.8	S	S	S
54671	"	Chert	15.2	S	S	S
54577	Slag	80 pound	23.2	S	S	S
54678	"	"	28.0	S	S	S
54676	"	71 pound	28.8	S	S	U
54670	Rock	Limestone	31.0	S	..	S
54675	"	"	34.8	S	..	S
54674	"	"	38.2	Q	U	U
54672	"	"	40.9	Q	..	U
54667	Gravel	Quartz	41.2	S	S	Q
54669	"	"	43.4	S	S	Q
54668	"	"	48.5	S	S	Q

Table 2 presents a comparison between the Los Angeles test result and the service record of materials used in surface treatment work based on data supplied by the Georgia State Highway Board. Both rock and blast furnace slag with Los Angeles losses of 40 per cent or less are found to have satisfactory service records.

Data furnished by the Kansas State Highway Commission giving service records for concrete and bituminous construction are shown in Table 3. All materials had satisfactory service records. The data indicate that satisfactory results were secured with materials having losses as high as 47.4 per cent in the case of concrete and 40.8 per cent in the case of bituminous construction.

TABLE 2

COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY GEORGIA STATE HIGHWAY BOARD

Type of material	Description	Los Angeles per cent of wear	Service record in surface treatment
Slag	Copper	14.6	S
Rock	Limestone	26.1	S
Slag	Blast furnace	27.3	S
Rock	Dolomite	38.2	S
"	Granite	40.2	S
Gravel	Quartz	49.1	U
Rock	Granite	61.9	U

Data furnished by the North Carolina State Highway and Public Works Commission regarding the behavior of materials in surface treatment construction are shown in Table 4. All materials found to be satisfactory for this use have percentages of wear in the Los Angeles test of less than 40.

TABLE 3

COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY KANSAS STATE HIGHWAY COMMISSION

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Concrete	Bituminous construction
27061	Rock	Limestone	30.8	S	S
27039	"	"	31.8	S	S
27069	"	"	32.4	S	S
27070	"	"	40.0	S	S
27071	"	Calcareous sandstone	40.8	S	S
27099	"	Limestone	47.4	S	..

TABLE 4

COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY NORTH CAROLINA STATE HIGHWAY AND PUBLIC WORKS COMMISSION

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Surface treatment
11	Rock	Granite	17.4	S
9	"	Limestone	19.9	S
8	"	"	21.3	S
10	"	Dolomitic limestone	24.2	S
7	"	Granite and diorite	36.4	S
2	"	Granite gneiss	37.9	S
12	Gravel	Quartz—gneiss	41.9	Q
13	"	Quartz	42.6	Q
3	Rock	Granite gneiss	47.1	U
16	Gravel	Quartz	47.6	Q
1	Rock	Dolomitic limestone	47.8	Q
4	"	Pegmatitic granite	50.6	Q
15	Gravel	Quartz	53.0	Q
14	"	"	54.1	Q
6	Rock	Granite	57.0	U
5	"	"	62.4	U

Table 5 presents data furnished by the Ohio Department of Highways showing the service record of materials in concrete and bituminous construction. With the exception of gravel from two sources, all materials with Los Angeles losses of less than 35 per cent are found suitable for use in the types of construction mentioned. No explanation of the behavior of these two questionable materials was furnished.

Service records for materials used in concrete, bituminous surfacing, and surface treatment are given in Table 6 based on information furnished by the South Carolina State Highway Department. These data show materials with Los Angeles losses of 41 per cent or less to be satisfactory for use in surface

treatment. Materials with losses to 46 per cent are considered satisfactory for use in bituminous con-

TABLE 5
COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY OHIO DEPARTMENT OF HIGHWAYS

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Concrete	Service record: Bituminous construction
9	Rock	Limestone	20.5	S	S
10	"	"	23.3	S	S
15	Slag	83.5 lb	27.9	S	S
11	Rock	Limestone	28.5	S	S
5	Gravel	Crushed	28.7	S	S
1	"		28.9	S	S
6	"	Crushed	29.6	S	S
2	"		31.0	Q	Q
16	Slag	72.5 lb	32.0	S	S
13	Rock	Limestone	32.7	S	S
3	Gravel		32.8	Q	Q
12	Rock	Limestone	33.2	S	S
4	Gravel		37.2	Q	Q
8	"	Crushed	38.8	Q	Q
17	Slag	69.5 lb	47.8	Q	Q
14	Rock	Limestone	58.0	Q	Q

struction and a rock with a loss of 67 per cent is considered suitable for use in concrete. Four samples of gravel with losses between 46 and 54 per cent are considered suitable for structural concrete only.

TABLE 6
COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY SOUTH CAROLINA STATE HIGHWAY DEPARTMENT

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Concrete	Service record: Bituminous construction	Service record: Surface treatment
A-21778	Rock	Granite	33.4	S	S	S
A-21781	"	"	34.8	S	S	S
A-23260	"	"	41.1	S	S	S
A-22269	Gravel	Siliceous	46.2	S[1]	Q	Q
A-22497	"	"	46.3	S[1]	S	..
A-22422	"	"	52.5	S[1]	U	U
A-22421	"	"	53.9	S[1]	U	U
A-21198	Rock	Dolomitic marble	58.2	S	..	..
A-22492	"	Gneiss	67.4	S	U	U
A-22423	Gravel	Siliceous	74.0	U	U	U

[1] For structural service only.

Data furnished by the Texas State Highway Department giving service records for materials used in concrete and bituminous construction are shown in Table 7. With only five exceptions all samples of rock and gravel with Los Angeles test losses of less than 45 per cent are found to be satisfactory for use in both types. The five exceptions include three limestones with losses of 30.2, 31.6 and 37.5 per cent, a siliceous gravel with a loss of 30.6 per cent, and a quartzite with a loss of 42.7 per cent. The limestone with a loss of 30.2 per cent is considered satisfactory for use in concrete but questionable for bituminous

TABLE 7
COMPARISON BETWEEN LOS ANGELES TEST RESULT AND SERVICE RECORD BY TEXAS STATE HIGHWAY DEPARTMENT

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record: Concrete	Service record: Bituminous construction
2979	Rock	Rhyolite	16.1	S	S
2992	"	Dolomitic	19.0	S	S
1934	Gravel	Siliceous	20.6	S	S
2951	"	"	22.2	S	S
3699	Rock	Limestone	22.2	S	S
2838	Gravel	Siliceous	24.5	S	S
2815	"	"	25.4	S	S
3557	"	"	25.6	S	S
3754	"	"	25.7	S	S
3723	Rock	Limestone	26.3	S	S
3672	"	"	26.9	S	S
3000	Gravel	Limestone and siliceous	27.0	S	S
2873	Rock	Limestone	27.2	S	S
3698	"	"	27.5	S	S
2243	Gravel	"	29.0	S	S
3092	Rock	"	29.1	S	S
2898	Gravel	Siliceous	30.0	S	S
2767	"	Limestone	30.1	S	S
3670	Rock	"	30.2	S	Q
3538	Gravel	Siliceous	30.6	Q	U
2975	Rock	Calcareous shale	30.8	S	S
2667	Gravel	Limestone	31.3	S	S
3766	Rock	"	31.6	U	U
3013	"	"	32.2	S	S
3823	"	"	33.2	S	S
3668	"	"	34.5	S	S
3783	"	"	35.1	S	S
3724	"	"	36.3	S	S
3803	"	Dolomite	36.3	S	S
3014	"	Limestone	37.5	Q	U
2367	Gravel	Siliceous	37.9	S	S
2824	Rock	Limestone	38.2	S	S
3228	"	"	39.3	S	S
3111	"	Quartzite	42.7	Q	Q
3824	"	Limestone	42.8	S	S
2368	Gravel	Siliceous	42.8	S	S
3229	Rock	Limestone	44.4	S	S
3805	"	"	46.9	Q	U
3725	"	"	49.2	Q	U
3816	"	"	50.5	Q	U
3015	"	"	54.3	U	U
2675	"	"	60.1	U	U
3669	"	"	62.0	U	U
2674	"	"	65.9	U	U

surfacing. The gravel is stated to be laminated, and this may account for its poor service record. Two of the three limestones were taken from sources which apparently contained material of variable quality, and it is possible that the low values given represent material of better quality than has been supplied for use. All materials with losses above 45 per cent are

stated to be unsuitable for bituminous construction and those above 51 per cent to be unsuitable for use in concrete.

Table 8 shows service record data for concrete, bituminous construction, and traffic bound surfacing furnished by the Wisconsin State Highway Department. The data are not complete in that service records for all three classes of construction are not shown for a majority of the materials. However, all materials with a Los Angeles loss of less than 40 per cent are stated to be satisfactory for use in those types of construction where a record is available. With the exception of one sample, a dolomite, all materials with losses of 47 per cent or less were reported

TABLE 8

Comparison Between Los Angeles Test Result and Service Record by Wisconsin State Highway Department

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record		
				Concrete	Bituminous construction	Traffic bound surfacing
1	Rock	Trap	11.1	S	S	S
4	Gravel	Igneous	18.4	S	..	..
5	Rock	"	18.9	..	..	S
6	Gravel	Mixed igneous	19.4	S	..	S
7	"	" "	19.4	S	..	..
8	"	" "	20.2	S	..	..
9	Rock	Dolomitic	21.8	..	..	S
10	Gravel	Mixed igneous	22.2	S	..	..
11	"	" "	22.3	S	..	..
12	"	Igneous	22.3	..	..	S
13	"	"	22.5	..	..	S
14	"	"	23.5	S	..	..
15	Rock	Dolomitic	25.1	S	S	S
16	Gravel	"	25.2	..	..	S
18	Rock	"	26.0	..	S	S
20	Gravel	"	27.3	S	..	S
21	"	Mixed igneous and sedimentary	27.7	..	..	S
22	Rock	Dolomitic	28.1	S	S	S
23	Gravel	"	28.2	S	..	S
24	Rock	"	28.4	..	..	S
25	Rock	"	28.4	..	..	S
27	Gravel	Mixed dolomitic and igneous	30.1	S	..	..
28	"	Dolomitic	30.6	S	..	..
29	Rock	"	30.8	..	..	S
30	Gravel	"	31.5	S	..	S
31	Rock	"	33.7	S	..	S
33	Gravel	Mixed dolomitic and igneous	34.1	S	..	..
34	Rock	....	35.3	..	S	..
35	Gravel	Dolomitic-igneous	35.5	S	..	..
37	"	Mainly dolomitic	36.1	..	..	S
38	Rock	Dolomitic	36.3	..	..	S
39	"	"	38.0	..	..	S
41	Gravel	Mainly dolomitic	39.3	S	..	..
43	Rock	Dolomitic	43.8	..	..	Q-U
46	"	"	47.2	..	..	S

as satisfactory for use in traffic bound surfacing. This surfacing was placed largely on town or county roads and presumably carried only light traffic.

In Table 9, the service record of materials used mainly in surface treatment construction is given from records furnished by the Country Roads Board

TABLE 9

Comparison Between Los Angeles Test Result and Service Record by Country Roads Board, State of Victoria, Australia

Sample No.	Type of material	Description	Los Angeles per cent of wear	Service record
9534	Rock	Basalt	12.4	Excellent
9708	"	"	12.9	"
9416	"	Dolerite	15.3	Very good
9359	"	Rhyolite	15.5	Satisfactory
9483	"	Basalt	16.8	Very good
9419	"	Dacite	18.1	Satisfactory
9349	"	Basalt	22.0	Good
9704	"	Limestone	23.5	Fair
9351	"	Basalt	24.3	Good
9472	"	"	24.3	Fair to good
9550	"	Sandstone	28.6	Fair
9348	"	Basalt	28.8	Fair
9350	"	"	30.0	Fair to good
9464	"	Granite	34.6	Fair
9275	Gravel	....	35.0	Fair
9352	Rock	....	37.0	Poor
9499	"	Quartz	41.0	Fair (light traffic)
9573	"	Sandstone	43.6	" " "
9345	"	Quartzite	44.0	" " "
9265	"	Shale	46.0	" " "
9357	"	Sandstone	54.8	" " "
....	"	Quartz	55.0	Poor

of the State of Victoria, Australia.[1] All rock and gravel with a Los Angeles loss of 35 per cent or less are stated to have excellent to fair service records, but the Board concludes that a maximum loss of 20 per cent should be used for the best surfacing materials.

A summation of the foregoing information is presented in Figure 1, with the findings of the different highway authorities grouped according to type of construction. Some liberties have been taken in presenting these data in that the values given may include a few materials without satisfactory service records. However, the attempt has been made to show a maximum value for the Los Angeles percentage of wear which includes all materials of satisfactory service record and excludes the majority of materials which have proved unsatisfactory. In general, it will be noted that the values given for bituminous surfacing are somewhat lower than those for concrete, and those for surface treatment are still

[1] The Los Angeles Abrasion Test, by A. H. Gawith, *Main Roads*, Vol. 8, No. 2, Feb. 1937, p. 54.

lower. This follows the general trend of the specification limits which have already been established for the Los Angeles test by several State Highway Departments.

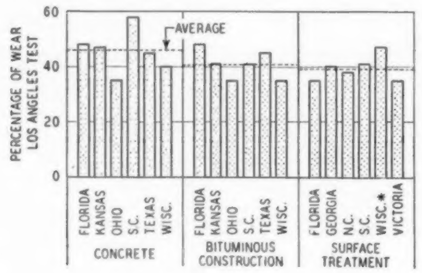


FIGURE 1.
Maximum Percentage of Wear in Los Angeles Test for Material of Satisfactory Service Record.

Comparisons With Other Tests

Figure 2 shows the results of tests made by the Michigan State College comparing the loss in the Los Angeles test with the loss in a circular track roller test. In both tests all materials were prepared with the following grading:

Passing	1½-inch	sieve,	per cent	....	100
"	1¼-inch	"	"	....	80
"	1-	"	"	....	60
"	¾-	"	"	....	40
"	½-	"	"	....	0

The material passing the No. 10 sieve after each test was considered as the loss and was expressed as a percentage of the original weight of the material. In the roller test, the samples were subjected to a maximum of 500 passes of a cast iron roller loaded to 200 lb. per inch of width. These results show a definite correlation between the two tests. It is interesting to note that 500 passes of the roller were required to secure a loss approaching that obtained in the Los Angeles test.

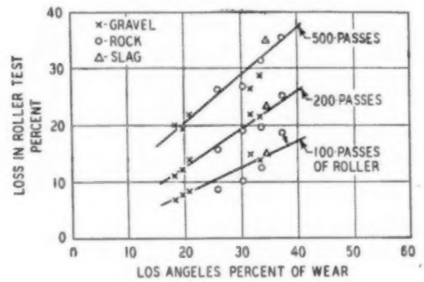


FIGURE 2.
Relation Between Losses in Los Angeles Test and Circular Track (Roller) Test. (Data from Michigan State College.)

*Traffic Bound Surfacing.

Data comparing the loss in the Los Angeles test with flexural or compressive strengths of concrete have been furnished by several State highway departments, and are shown in Figures 3 to 6, inclusive. In Figure 3 flexural test results representing a large number of tests made by the Georgia State Highway Department over a period of three years show a very good correlation with the results of the Los Angeles test. Proportions specified by Georgia for concrete pavement construction were used in this work. Figure 4 presents the results of a laboratory investigation made in Texas with four different aggregates: a hard limestone with a Los Angeles loss of 29.1 per cent, a blue-gray quartzite with a loss of 33.1 per cent, a red sandstone with a loss of 70 per cent, and a soft limestone with a loss of 74.2 per cent. The materials were prepared to approximately the same grading, and made into concrete with three different mixes using 5, 7, and 9 gallons of water per sack of cement. Due to differences in the aggregates,

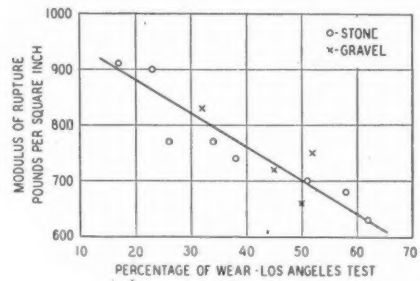


FIGURE 3.
Relation Between Flexual Strength of Concrete and Los Angeles Abrasion Loss. (Data from Georgia State Highway Department.)

slightly different cement factors (sacks per cubic yard of concrete) were obtained for each water content. The average cement factor for the 9-gallon mix was about 1.0 bbl.; for the 7-gallon mix it was about 1.2 bbl. and for the 5-gallon mix it was about 1.7 bbl. To permit ready comparison with other data these average cement factors have been indicated in the figures in place of the governing water content. It will be noted that the effect of quality of aggregate is more pronounced in the rich mix than in either of the others. This tendency is also revealed in Figure 5 which shows the corresponding relation between Los Angeles abrasion loss and crushing strength.

Figure 6 gives the results of a series of tests involving samples of granite and limestone from nine commercial quarries in North Carolina. Similar relations to those indicated in Figure 4 are found. These data emphasize the importance of taking into consideration the influence of the quality of the coarse aggregate in connection with the design of paving mixtures. In the case of the nine commercial crushed stones in North Carolina a maximum difference of about 150 lb. in modulus of rupture resulted when the cement content was held constant at 1.5 bbl. Mixes designed for strength would compensate for this as well as other variables inherent in the method of arbitrary proportioning. However it should be recognized that characteristics of aggregates other than resistance to abrasion such as, for example, surface texture, will also affect the strength of concrete.

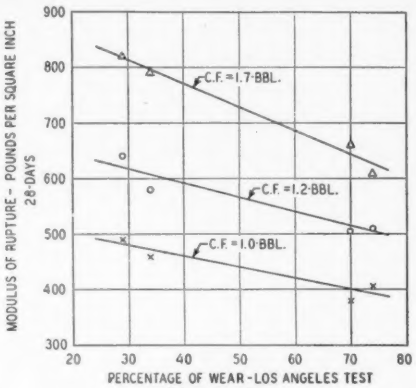


FIGURE 4.

Relation Between Los Angeles Abrasion Loss and Flexual Strength of Concrete. (Data from Texas State Highway Department.)

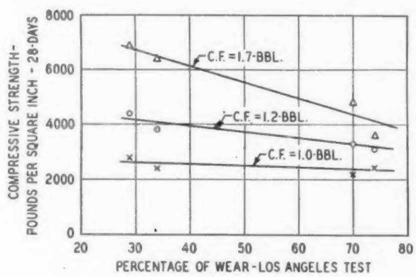


FIGURE 5.

Relation Between Los Angeles Abrasion Loss and Compressive Strength of Concrete. (Data from Texas State Highway Department.)

Data furnished by the Pennsylvania Department of Highways comparing the Los Angeles test result with determinations of the amount of soft or friable particles in gravel are given in Figure 7. In the test for soft pieces, particles between ⅝ in. and 1¼ in. were loaded without impact to a total of 200 lb., and larger particles to 400 lb. Particles which crushed under these loads were considered to be soft or friable. A definite relationship is found between the test for soft pieces and the Los Angeles test although several samples depart somewhat from the general trend.

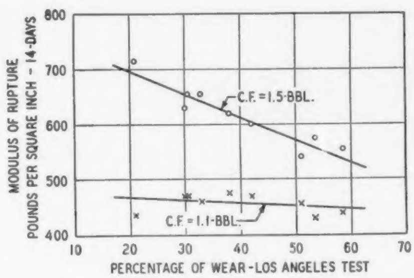


FIGURE 6.

Relation Between Los Angeles Abrasion Loss and Flexual Strength of Concrete. (Data for Crushed Stone from Nine Commercial Quarries in N. Carolina.)

Conclusion

Some difficulty was found in attempting to summarize the data discussed in this paper. This is due to the fact that all states do not have the same range in quality of coarse aggregates, and one state with an abundance of hard rock will consider certain test values for quality as necessary which could not be used by other states. Consequently it must be emphasized that recommendations given here are subject to change to suit local conditions.

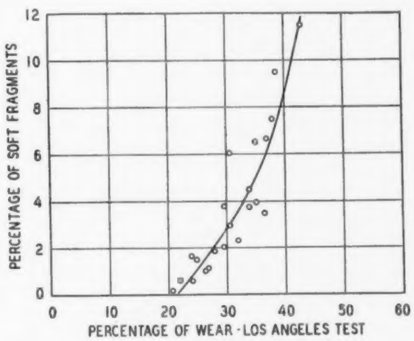


FIGURE 7.

Relation Between Percentage of Soft Fragments in Gravel and Los Angeles Abrasion Loss. (Data from Pennsylvania State Highway Department.)

In general, it appears that there is a definite relation between the loss in the Los Angeles test and the service record of materials used in concrete, bituminous construction and surface treatment. On the basis of the data available, the following percentages of wear appear to be suitable for use in specifications to control the quality of coarse aggregates:

	Per cent
Concrete	50
Bituminous surfacing	40
Surface treatment	40

Definite correlations between the loss in the Los Angeles test and the strength of concrete are found, the lower the percentage of wear the higher the concrete strength. Definite correlations are also found with the results of a circular track roller test and a test for soft or friable pieces.

In conclusion, it appears that the Los Angeles test gives accurate indication of the quality of the material under test, and that its use in specifications controlling the acceptance of coarse aggregates is warranted.

Discussion of Preceding Article

By A. T. GOLDBECK

Engineering Director, National Crushed Stone Association

IT SHOULD go without saying that any test designed to indicate the desirability of a construction material should give results which bear a close relationship to the behavior of that material when it is used in service. Such a statement may seem trite and yet all too frequently tests for materials have not complied with that very desirable and fundamental requirement. So far as the writer can recall, in no other test for aggregate has so much effort been made to determine the relation between test results and service behavior as has been exerted in the case of the Los Angeles Abrasion Test. The difficulties of establishing a relationship with the definiteness so earnestly desired by materials engineers who are trained to exactness, may well be imagined. Differences in construction procedure, in traffic intensity, in climate and in the personal equation of the local observer because of his particular familiarity with materials in a given locality,—all are bound to influence reports on service behavior. Then, too, exceptions to general trends in behavior are always apt to creep into the picture to influence the final coordination. These exceptions must be run to earth to discover the reasons for deviation from what may appear to be a trend toward a general rule.

The procedure followed by the Committee on Correlation of Research in Mineral Aggregates of the Highway Research Board, and reported by Mr. Woolf, who analyzed the reports submitted to the Committee by various highway departments, is to be highly commended. Through the method pursued by the Committee, correlative results have been received from widely scattered sections of the United States and even from Australia. Thus a wide range in materials has been considered, as well as a wide range in traffic conditions. As a result of these reports it now seems to be established that:

1. There is a relationship between Los Angeles rattler test results and the service behavior of the various aggregates when used in concrete highways, in bituminous construction and in traffic-bound surfacing.
2. The beam strength of concrete is influenced by the quality of the coarse aggregate as determined by the Los Angeles rattler.

The investigations made by the National Crushed Stone Association bear out, in a general way, the conclusions stated in Mr. Woolf's report. In our bulletin No. 9, published in March 1936, entitled, "Tests for the Traffic Durability of Bituminous Pavements," tests are described showing the correlation of the resistance to crushing under a roller and Los Angeles rattler results obtained on materials used in the roller test. The correlation obtained was very striking. Those materials which crushed badly under the roller had a high Los Angeles rattler loss while those which resisted the action of the roller showed a low loss in the Los Angeles rattler. It was also shown that this same coordination did not exist with our old time-honored methods for testing stone, namely, the Deval Abrasion Test and the Toughness Test.

Our tests also show a relationship between the Los Angeles rattler and beam strength using vi-

brated concrete. The following tests were performed in 1934 and 1935 and form a part of Series I in a group of three series of tests made on concrete containing commercially produced aggregates received from different portions of one of the Eastern States. They include crushed stone, slag and siliceous types of gravel. The properties of the fine and coarse aggregates used are given in Table I. The same fine aggregate, a natural siliceous sand, was used in all of the concrete mixtures.

The concrete was designed for placing by vibration. Its theoretical cement factor was 5.5 bags of cement per cu. yd. and the value of b/b_0[1] was 0.83; b_0 was determined on a dry, rodded volume basis. An effort was made to obtain about the same consistency, as nearly as practicable, and this necessarily resulted in a different water-cement ratio for the various mixes. The concrete was mixed by the use of shovels and it was placed in a 6 in. by 6 in. by 38 in. beam mold clamped on the vibrating machine as shown in Fig. 1. This machine consists of a 6 in. standard steel channel 5 feet long mounted with its ends entirely encased in soft rubber. The ends are clamped down so that the only motion possible is due to the compression of the rubber. To the bottom of the table, at the center, is mounted the vibrating unit. It is essentially an off-center fly-wheel made eccentric by the addition of bolts to one side and their omission from the opposite side of the wheel. The shaft carrying the off-center fly-wheel is mounted in four sets of ball bearings, two on each side. Power is furnished by a 2 H. P. electric motor through a flat-belt drive. The fly-wheel turns at the rate of 4000 r.p.m. thus giving the vibration table a frequency of over 4000 vibrations per minute. The amplitude or "throw" of the table is approximately 1/32 inch; compression cylinders were molded at the same time as the beams.

The molding procedure consisted of filling all three molds, 1 beam and 2 cylinder molds, one-third

(1) b = solid volume of coarse aggregate in a cubic foot of concrete.
b_0 = solid volume of coarse aggregate in a cubic foot of coarse aggregate.

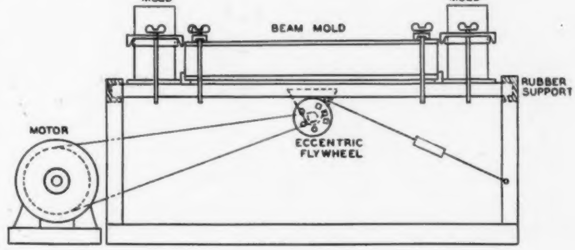


FIGURE 1.
Diagrammatic view of vibration machine.

TABLE I.

TESTS ON PHYSICAL PROPERTIES OF AGGREGATES
COARSE AGGREGATE

Lab. No.	Material	Specific Gravity	Pounds per Cubic Foot: Loose	Rodded	Shaken	Gradation—Total Per cent Passing: 2¾"	2½"	1¼"	⅝"	⅜"	Per cent Wear Los Angeles Rattler
572	Stone	2.99	104.0	113.0	117.3	100	97	46	11	4	----
574	Slag	1.96	66.3	72.9	73.4	100	100	38	3	2	30.1
575	Stone	2.73	96.0	104.7	106.7	100	98	47	13	3	20.0
579	Cr. Gravel	2.58	102.1	109.0	110.4	100	97	53	16	4	25.9
580	40%+ Cr. Gravel	2.58	95.6	104.2	106.8	100	100	53	18	4	27.6
591	Stone	2.79	92.8	102.5	105.5	100	99	46	5	1	24.8
596	Slag	2.60	85.0	96.1	97.9	100	100	46	13	5	24.3
585	Stone	2.68	86.9	95.2	97.1	100	99	40	1	0	20.4
590	Stone	2.78	93.8	103.4	106.9	100	99	45	7	1	24.8
600	Cr. Gravel	2.68	95.5	104.0	106.8	100	100	49	12	1	25.5
597	Cr. Gravel	2.58	90.3	98.9	101.2	100	100	86	12	2	----
576	Slag	2.17	71.2	78.1	80.5	100	97	25	3	1	30.8
589	Stone	2.69	92.7	101.0	104.1	100	99	51	10	3	26.1
570	Slag	2.17	71.6	79.1	82.7	100	100	36	12	8	33.0
571	Slag	2.26	75.7	82.5	84.2	100	100	35	3	2	32.8
578	Stone	2.70	88.0	97.5	99.7	100	100	57	13	1	23.2
582	Cr. Gravel	2.50	90.8	99.7	102.3	100	97	24	4	2	45.3
584	Gravel	2.50	97.9	104.4	106.7	100	99	49	6	2	32.4
586	Gravel	2.50	96.3	103.4	105.4	100	96	32	2	0	28.8
587	Cr. Gravel	2.53	94.3	101.1	103.9	100	96	27	3	1	41.6

FINE AGGREGATE

Lab. No.	Material	Specific Gravity	Loose	Rodded	Shaken	#4	#8	#16	#30	#50	#100	Elutriation
581	Natural sand	2.68	99.1	104.5	110.1	98	84	72	51	12	1	0.6

Coarse aggregate gradations in round openings.

TABLE II.
CONCRETE PROPORTIONS AND MODULUS OF RUPTURE (28 DAYS)
VIBRATED CONCRETE
(Designed for 5.5 bags of cement per cu. yd.; $b/b_o = 0.83$; b_o value based on dry, rodded volume.)

Mix No.	Proportions by Dry, loose volume Cement	F.A.	C.A.	Cement Bags per Cu. Yd.	W/C	Slump In.	Flow	Modulus of Rupture	Type of Coarse Aggregate	Per cent Loss Los Angeles Rattler
1	1	2.00	4.45	5.50	0.71	0.5	143	772	Cr. Stone	....
2	1	2.14	4.48	5.54	0.69	0.8	134	756	Slag	30.1
3	1	2.04	4.46	5.42	0.70	0.5	137	844	Cr. Stone	20.0
4	1	1.65	4.38	5.45	0.65	1.2	140	838	Cr. Gravel	25.9
5	1	1.81	4.47	5.44	0.65	1.2	137	789	Cr. Gravel	27.6
6	1	2.12	4.52	5.46	0.74	1.2	136	829	Cr. Stone	24.8
7	1	2.10	4.62	5.48	0.71	0.9	133	823	Slag	24.3
8	1	2.24	4.46	5.43	0.74	1.0	140	791	Cr. Stone	20.4
9	1	2.12	4.52	5.42	0.71	0.8	138	800	Cr. Stone	24.8
10	1	1.98	4.43	5.45	0.69	0.8	132	816	Cr. Gravel	25.5
11	1	2.01	4.47	5.44	0.67	0.8	133	792	Cr. Gravel	....
12	1	2.22	4.47	5.45	0.70	0.6	133	776	Slag	30.8
13	1	2.06	4.44	5.44	0.72	1.2	142	818	Cr. Stone	26.1
14	1	2.16	4.50	5.54	0.69	0.9	131	777	Slag	33.0
15	1	2.16	4.46	5.55	0.70	0.8	133	756	Slag	32.8
16	1	2.17	4.53	5.45	0.72	0.2	134	779	Cr. Stone	23.2
17	1	1.92	4.48	5.47	0.62	0.6	133	684	Cr. Gravel	45.3
18	1	1.74	4.36	5.45	0.61	1.2	136	668	Gravel	32.8
19	1	1.77	4.39	5.49	0.65	1.1	135	734	Gravel	28.8
20	1	1.90	4.38	5.43	0.65	0.6	136	726	Cr. Gravel	41.6

full, then vibrating for 5 seconds, then two-thirds full followed by 5 seconds additional vibration and finally the molds were filled to over-flowing and subjected to 20 seconds of vibration, during which time the operators struck off the tops of the specimens with a wood float. This procedure was arrived at after trying a number of different methods, but that finally adopted seemed to produce specimens most nearly free of air or water voids in the surface adjacent to the forms.

The specimens were stored for 28 days in the moist room and were tested as simple beams with a single load applied at the center on a span length of 18 inches. A Southwark-Emery hydraulic testing machine was used for the application of the load. The beams were loaded at the rate of 25 pounds central load per second. Each beam was tested 3 times with the bottom side as molded in tension. The modulus of rupture was calculated for the center of the span. Each result for modulus of rupture, shown in Table II, represents the average of nine tests.

The relationship between modulus of rupture and the Los Angeles rattler results is shown in Fig. 2. It will be noted that there is a general tendency toward decreased values for modulus of rupture with increased values in the Los Angeles rattler test. In all probability the surface characteristics of the coarse aggregate influenced the results as well as the physical characteristics, expressed in terms of Los Angeles rattler loss.

There is one feature of Mr. Woolf's report which should be emphasized, namely, those Los Angeles rattler test values which are stated as limits are intended as *limits* and *not* as specification values which should be used everywhere irrespective of the quality of the aggregates obtainable in a given locality or a given State. These limits define the worst materials to be tolerated and not the kind of materials which are always desired. Naturally, it is to be expected that materials with a lower Los Angeles rattler loss than the limiting materials, will give better service results. Accordingly, where the predominating material in a State permits of more

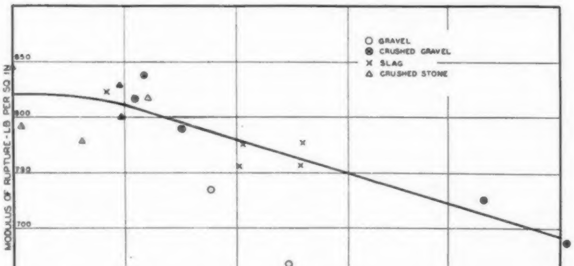


FIGURE 2.
Per cent wear—Los Angeles Rattler.

stringent requirements, lower abrasion losses should be specified so as to insure the use of the high class, economically obtainable aggregates.

The National Crushed Stone Association Safety Competition of 1937

By W. W. ADAMS

Supervising Statistician Employment Statistics Section U. S. Bureau of Mines

◆ Columbia Quarry Co. wins contest for third successive year. Twelve other plants with perfect records accorded Honorable Mention.

THE crushed-stone producers' safety contest of 1937, conducted by the Bureau of Mines in cooperation with the National Crushed Stone Association, resulted in a marked reduction in the frequency of accidents among men employed at the quarries and crushing plants. Records submitted to the Bureau of Mines by the companies enrolled in the contest revealed a reduction of 22 percent in the accident-frequency rate. On the other hand, the accident-severity rate was higher than in 1936 due to an increase of 2 in the number of fatalities during 1937, and the heavy weighting in days lost chargeable for each fatality in computing the severity rate.

The trophy is awarded annually to the plant establishing the lowest accident-severity rate, that is, the fewest days lost from accidents per 1,000 man-hours of employment or exposure to risk. When two or more plants operate without a lost-time accident, the best record is considered to be that showing the largest number of man-hours worked; all other plants having accident-free records are awarded certificates of honorable mention.

The winning plant for the 1937 contest was the Krause No. 1 limestone quarry, St. Clair County, Illinois, near Columbia, Monroe County, Illinois. This plant was operated by the Columbia Quarry Company and worked 219,069 man-hours during 1937 without a lost-time accident. This is the third successive year that the Krause quarry has won the National Crushed Stone Association safety trophy, and it is the fifth successive year that the plant has operated without a lost-time accident. The total volume of employment during the five years amounted to 946,067 man-hours. The quarry has been enrolled in the contest since 1931 and has not had a lost-time accident since September 22, 1932.

In addition to the Krause quarry, nine other open quarries and two underground mines were operated throughout the year 1937 with accident-free records, and each plant, except the trophy winner, was therefore awarded a certificate of honor. The plants awarded these certificates were:

1.—Winnsboro granite quarry, Winnsboro, Fairfield County, South Carolina, operated by the South Carolina Granite Company. The quarry worked 179,661 man-hours in 1937.

2.—Piqua limestone quarry, Piqua, Miami County, Ohio, operated by the Ohio Marble Company. The quarry worked 145,132 man-hours in 1937.

3.—Bell limestone mine, Bellefonte, Centre County, Pa., operated by the American Lime & Stone Company. The mine worked 112,526 man-hours in 1937.

4.—Marquette limestone quarry, Cape Girardeau, Cape Girardeau County, Missouri, operated by the Marquette Cement Manufacturing Company. The quarry worked 97,824 man-hours in 1937.

EMPLOYEES OF KRAUSE QUARRY NO. 1, COLUMBIA, ILLINOIS. WINNERS OF 1937 NATIONAL CRUSHED STONE ASSOCIATION CONTEST.

5.—Pixley limestone mine, Independence, Jackson County, Missouri, operated by the Stewart Sand and Material Company. The mine worked 87,384 man-hours in 1937.

6.—Rolesville granite quarry, Wake Forest, Wake County, North Carolina, operated by the Southern Aggregates Corporation. The quarry worked 83,207 man-hours in 1937.

7.—White Haven sandstone quarry, White Haven, Luzerne County, Pa., operated by the General Crushed Stone Company. The quarry worked 80,506 man-hours in 1937.

8.—Akron limestone quarry, Akron, Erie County, New York, operated by the General Crushed Stone Company. The quarry worked 56,444 man-hours in 1937.

9.—Plainville No. 4 trap rock quarry, Plainville, Hartford County, Conn., operated by the New Haven Trap Rock Company. The quarry worked 47,342 man-hours in 1937.

TABLE 1.

RELATIVE STANDING OF PLANTS IN THE 1937 NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, BASED UPON THE ACCIDENT-SEVERITY RATES OF THE PLANTS (QUARRY GROUP)[1]

Code No.	Group No.	Hours worked	Number of accidents					Number of days lost					Frequency rate	Severity rate
			Fatal	P.T.	P.P.	Temp.	Total	Fatal	P.T.	P.P.	Temp.	Total		
1	1	219,069	----	----	----	----	----	----	----	----	----	----	.000	.000
2	2	179,661	----	----	----	----	----	----	----	----	----	----	.000	.000
3	3	145,132	----	----	----	----	----	----	----	----	----	----	.000	.000
5	4	97,824	----	----	----	----	----	----	----	----	----	----	.000	.000
7	5	83,207	----	----	----	----	----	----	----	----	----	----	.000	.000
8	6	80,506	----	----	----	----	----	----	----	----	----	----	.000	.000
9	7	56,444	----	----	----	----	----	----	----	----	----	----	.000	.000
10	8	55,064	----	----	----	----	----	----	----	----	----	----	.000	.000
11	9	47,342	----	----	----	----	----	----	----	----	----	----	.000	.000
12	10	17,814	----	----	----	----	----	----	----	----	----	----	.000	.000
13	11	17,616	----	----	----	----	----	----	----	----	----	----	.000	.000
14	12	152,985	----	----	----	1	1	----	----	----	11	11	6.537	.072
15	13	199,176	----	----	----	1	1	----	----	----	30	30	5.021	.151
16	14	58,101	----	----	----	1	1	----	----	----	9	9	17.211	.155
17	15	66,035	----	----	----	1	1	----	----	----	11	11	15.143	.167
18	16	164,596	----	----	----	2	2	----	----	----	28	28	12.151	.170
19	17	230,254	----	----	----	1	1	----	----	----	42	42	4.343	.182
20	18	78,233	----	----	----	2	2	----	----	----	17	17	25.565	.217
21	19	251,732	----	----	----	9	9	----	----	----	55	55	35.752	.218
22	20	72,079	----	----	----	3	3	----	----	----	17	17	41.621	.236
23	21	188,524	----	----	----	3	3	----	----	----	68	68	15.913	.361
24	22	111,150	----	----	----	3	3	----	----	----	60	60	26.991	.540
25	23	93,436	----	----	----	1	1	----	----	----	51	51	10.703	.546
27	24	282,445	----	----	----	10	10	----	----	----	194	194	35.405	.687
28	25	534,087	----	----	1	1	2	----	----	300	70	370	3.745	.693
29	26	230,131	----	----	----	1	1	----	----	----	168	168	4.345	.730
30	27	112,015	----	----	----	4	4	----	----	----	83	83	35.710	.741
31	28	104,400	----	----	----	2	2	----	----	----	101	101	19.157	.967
32	29	147,059	----	----	----	6	6	----	----	----	144	144	40.800	.979
33	30	306,541	----	----	----	8	8	----	----	----	368	368	26.098	1.200
34	31	116,616	----	----	----	20	20	----	----	----	143	143	171.503	1.226
35	32	99,796	----	----	----	8	8	----	----	----	131	131	80.164	1.313
36	33	56,011	----	----	----	2	2	----	----	----	75	75	35.707	1.339
37	34	102,141	----	----	----	4	4	----	----	----	199	199	39.162	1.948
38	35	294,661	----	----	1	4	5	----	----	300	309	609	16.969	2.067
39	36	16,622	----	----	----	1	1	----	----	----	40	40	60.161	2.406
40	37	171,879	----	----	----	3	3	----	----	----	513	513	17.454	2.985
41	38	194,396	----	----	----	14	14	----	----	----	602	602	72.018	3.097
42	39	88,359	----	----	----	3	3	----	----	----	394	394	33.952	4.459
43	40	127,243	----	----	1	--	1	----	----	750	----	750	7.859	5.894
44	41	203,149	----	----	2	9	11	----	----	900	449	1,349	54.147	6.640
45	42	102,531	----	----	1	6	7	----	----	1,000	61	1,061	68.272	10.348
46	43	36,207	----	----	1	--	1	----	----	1,800	----	1,800	27.619	49.714
47	44	74,737	1	----	1	2	4	6,000	----	750	18	6,768	53.521	90.558
48	45	73,537	2	----	----	----	2	12,000	----	----	----	12,000	27.197	163.183
49	46	36,254	1	----	----	----	1	6,000	----	----	----	6,000	27.583	165.499
50	47	21,204	3	----	1	----	4	18,000	----	75	----	18,075	188.644	852.434
Totals and rates, 1937		6,199,001	7	0	9	136	152	42,000	0	5,875	4,461	52,336	24.520	8.443
Totals and rates, 1936		6,399,023	5	0	14	182	201	30,000	0	8,168	4,590	42,758	31.411	6.682

[1] As the accident reports from mining companies are considered confidential by the Bureau of Mines, the identities of the plants to which this table relates are not revealed. Frequency rate indicates number of fatal, permanent, and other lost-time accidents per million man-hours of exposure; severity rate indicates number of days lost from accidents per thousand man-hours.

Note: P. T. means permanent total disability; P.P. means permanent partial disability; and Temp. means temporary disability.

TABLE 2.

RELATIVE STANDING OF PLANTS IN THE 1937 NATIONAL CRUSHED STONE ASSOCIATION SAFETY COMPETITION, BASED UPON THE ACCIDENT-SEVERITY RATES OF THE PLANTS (UNDERGROUND—MINE GROUP)[1]

Code No.	Group No.	Hours worked	Number of accidents: Fatal	P.T.	P.P.	Temp.	Total	Number of days lost: Fatal	P.T.	P.P.	Temp.	Total	Frequency rate	Severity rate
4	1	112,526	----	----	----	----	----	------	----	----	----	----	.000	.000
6	2	87,384	----	----	----	----	----	------	----	----	----	----	.000	.000
26	3	164,770	----	----	----	3	3	------	----	----	91	91	18.207	.552
Totals and rates, 1937		364,680	0	0	0	3	3	0	0	0	91	91	8.226	0.250
Totals and rates, 1936		334,747	1	0	0	7	8	6,000	0	0	117	6,117	23.899	18.274

[1] As the accident reports from mining companies are considered confidential by the Bureau of Mines, the identities of the plants to which this table relates are not revealed. Frequency rate indicates number of fatal, permanent, and other lost-time accidents per million man-hours of exposure; severity rate indicates number of days lost from accidents per thousand man-hours.

Note: P.T. means permanent total disability; P.P. means permanent partial disability; and Temp. means temporary disability.

10.—Rocky Hill No. 3 trap rock quarry, Rocky Hill, Hartford County, Conn., operated by the New Haven Trap Rock Company. The quarry worked 17,814 man-hours in 1937.

11.—Howes Cave limestone quarry, Howes Cave, Schoharie County, New York, operated by the North American Cement Corporation. The quarry worked 17,616 man-hours in 1937.

Eighteen states, as listed below, were represented in the National Crushed Stone Association safety contest in 1937:

California	Michigan	Pennsylvania
Connecticut	Missouri	South Carolina
Georgia	New York	Tennessee
Illinois	North Carolina	Texas
Maryland	Ohio	Virginia
Massachusetts	Oklahoma	West Virginia

TABLE 3.

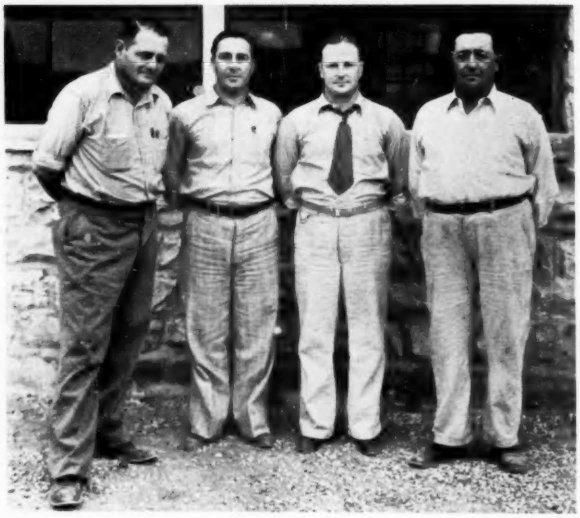
YEARLY SUMMARY—NATIONAL CRUSHED STONE ASSOCIATION SAFETY CONTEST, 1926-1937

Year	Plants	Hours worked	Number of accidents[2]: Fatal	P.T.	P.P.	Temp.	Total	Number of days lost[2]: Fatal	P.T.	P.P.	Temp.	Total	Frequency rate[1]	Severity rate[1]
OPEN QUARRIES														
1925[3]	38	4,927,402	4	----	3	292	299	24,000	----	3,600	5,286	32,886	60.681	6.674
1926	40	5,298,983	3	----	6	207	216	18,000	----	9,000	4,239	31,239	40.763	5.895
1927	48	7,876,791	9	----	2	458	469	54,000	----	2,100	7,186	63,286	59.542	8.034
1928	53	7,509,098	8	----	4	322	334	48,000	----	8,700	5,493	62,193	44.479	8.282
1929	53	7,970,325	4	----	5	286	295	24,000	----	5,760	5,533	35,293	37.012	4.428
1930	68	8,013,415	6	----	9	227	242	36,000	----	7,250	3,671	46,921	30.199	5.855
1931	58	5,085,857	4	----	13	198	215	24,000	----	18,660	3,540	46,200	42.274	9.084
1932	40	2,661,850	1	----	4	75	80	6,000	----	6,750	2,481	15,231	30.054	5.722
1933	40	2,704,871	1	----	1	67	69	6,000	----	48	2,893	8,941	25.510	3.306
1934	46	3,288,257	1	----	2	106	109	6,000	----	2,850	1,873	10,723	33.148	3.261
1935	46	4,166,306	2	1	8	77	88	12,000	6,000	9,900	3,015	30,915	21.122	7.420
1936	50	6,399,023	5	----	14	182	201	30,000	----	8,168	4,590	42,758	31.411	6.682
1937	47	6,199,001	7	----	9	136	152	42,000	----	5,875	4,461	52,336	24.520	8.443
Total 13 years		72,101,179	55	1	80	2,633	2,769	330,000	6,000	88,661	54,261	478,922	38.404	6.642
UNDERGROUND MINES														
1925[3]	3	400,672	--	----	--	29	29	------	----	----	228	228	72.378	0.569
1926	3	517,926	--	----	--	34	34	------	----	----	533	533	65.646	1.029
1927	2	318,449	1	----	1	14	16	6,000	----	300	68	6,368	50.244	19.997
1928	5	542,193	1	----	1	68	70	6,000	----	300	888	7,188	129.105	13.257
1929	4	665,520	1	----	1	30	32	6,000	----	300	617	6,917	48.083	10.393
1930	6	595,367	1	----	1	15	17	6,000	----	225	468	6,693	28.554	11.242
1931	3	345,105	--	----	--	4	4	------	----	----	147	147	11.591	.426
1932	2	158,450	--	----	--	6	6	------	----	----	165	165	37.867	1.041
1933	3	229,381	--	----	--	11	11	------	----	----	349	349	47.955	1.521
1934	4	248,146	--	----	--	13	13	------	----	----	287	287	52.389	1.157
1935	2	175,994	--	----	--	3	3	------	----	----	249	249	17.046	1.415
1936	4	334,747	1	----	--	7	8	6,000	----	----	117	6,117	23.899	18.274
1937	3	364,680	--	----	--	3	3	------	----	----	91	91	8.226	0.250
Total 13 years		4,896,630	5	0	4	237	246	30,000	0	1,125	4,207	35,332	50.239	7.216

[1] Frequency rate indicates the number of fatal, permanent, and other lost-time accidents per million man-hours of exposure; severity rate indicates the number of days lost from accidents per thousand man-hours.
[2] P.T., permanent total disability; P.P., permanent partial disability; Temp., temporary disability.
[3] The National Crushed Stone Association safety contest began in 1926; figures for 1925 for company members are given for comparison.

By T. D. Lawrence and E. E. Getzin. Under supervision of W. W. Adams, Employment Statistics Section, Mineral Production and Economics Division.

During 1937 there were 155 lost-time accidents at the 47 open quarries and 3 underground mines enrolled in the contest, including seven fatal and nine permanent partial injuries. The total time lost was



QUARRY NO. 1 EMPLOYEES. READING LEFT TO RIGHT—C. E. KLAUS, SUPT.; R. C. HEISE, CLERK; E. A. HEISE, SAFETY ENGR.; PASQUALE GIANI, FOREMAN.

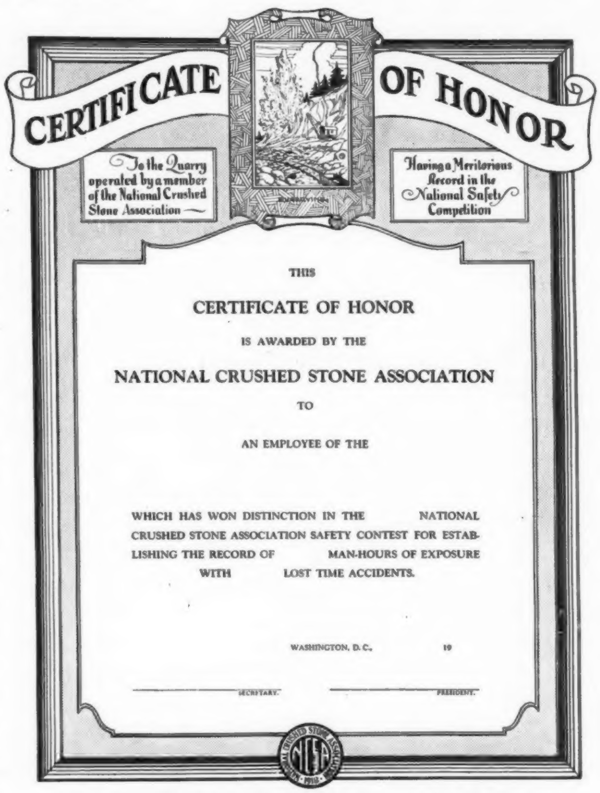
52,427 days. Based on 6,563,681 man-hours worked, the above figures indicate an accident-frequency rate of 23.6 per million man-hours and an accident-severity rate of 7.99 per thousand man-hours. For open quarries the rates were 24.5 and 8.44, a marked decline in frequency from the rate of 31.4 in the previous year, but an increase in severity compared with the previous year's rate of 6.68. The present year's frequency rate has only been exceeded by one other year during the period of the contests (1935) and it is forty percent better than the rate for the first contest year twelve years ago.

Since only a few underground mines are entered each year it is impossible to make a comparison of their accident rates with open quarries for any one year. However the totals over a 13-year period may be compared, and they show that the average frequency for open quarries was 38.4, while that for underground mines was 50.2, indicating that underground mining was about 30 percent more hazardous than open quarrying. The injuries also tended to be more severe, as average severity rates for the two classes of plants were 6.64 and 7.22, respectively.

Of the 50 plants enrolled in the contest, 13 had accident-free records, and these plants accounted for 18 percent of the 6,563,681 man-hours worked by all plants.

Over a 13-year period for which records are available, (contest years 1926-37 and the year 1925 preceding the contests), the average length of a temporary injury at open quarries was 20.6 days, while the average time lost per accident, including fatal and permanent injuries was 173 days. No compilation showing the causes of the accidents at plants enrolled in the contest has been made; however, tables of accidents by causes at crushed stone plants in general are published in yearly bulletins entitled "Quarry Accidents in the United States," published by the Bureau of Mines.

Tables 1 and 2 show the relative standing of the open-quarries and underground mines, arranged according to the accident-severity rates of the various plants. Table 3 presents comparative statistics for all participating quarries and mines during a period of 13 years.



CERTIFICATE OF HONOR

To the Quarry operated by a member of the National Crushed Stone Association —

Having a Meritorious Record in the National Safety Competition

THIS

CERTIFICATE OF HONOR

IS AWARDED BY THE

NATIONAL CRUSHED STONE ASSOCIATION

TO

AN EMPLOYEE OF THE

WHICH HAS WON DISTINCTION IN THE NATIONAL CRUSHED STONE ASSOCIATION SAFETY CONTEST FOR ESTABLISHING THE RECORD OF MAN-HOURS OF EXPOSURE WITH LOST TIME ACCIDENTS.

WASHINGTON, D. C. 19

SECRETARY. PRESIDENT.

Presented to Each Employee of Each Plant Completing the Year with No Lost Time Accidents.

Crushed and Broken Stone in 1937

By OLIVER BOWLES and
A. T. COONS
Non Metal Economics Division
U. S. Bureau of Mines

THE total output of crushed and broken stone in the United States in 1937 amounted to 131,262,010 short tons valued at $121,880,591, an increase of one per cent in quantity and 3 per cent in value over 1936, Bureau of Mines figures show. This industry covers such diverse products as stone sold or used for concrete aggregates, railroad ballast, riprap, agricultural limestone, refractory stone, and stone for metallurgical use (flux), alkali works, calcium carbide works, sugar and glass factories, paper mills, and various other chemical and manufacturing processes. It does not, however, include stone used in the manufacture of lime or cement, asphaltic stone, or slate used for granules or flour, which would increase the total to nearly 170,000,000 tons.

Over 67 per cent of the crushed or broken stone reported in 1937 was for concrete aggregates and railroad ballast—88,432,570 tons valued at $82,824,608. About 30 per cent of the concrete and road making aggregates is noncommercial, produced by contractors or crews maintained by various governmental agencies. There was an increase of 8 per cent in commercial production and a decrease of 12 per cent in noncommercial production of these aggregates in 1937, as compared with 1936. The average unit value of the commercial product decreased 5 cents a ton and that of the noncommercial product increased 11 cents a ton.

In 1937 about 61 per cent of the commercial aggregates was reported as transported by truck; 26 per cent by railroads; 9 per cent by water; and the remainder unspecified. The corresponding figures for 1936 were: Truck, 57 per cent; railroad, 30 per cent; and water, 7 per cent.

Metallurgical stone (21,331,970 tons valued at $14,704,458), which comprised over 16 per cent of the total crushed or broken stone, increased 20 per cent in tonnage. The greater part of this stone is used as flux by blast furnaces but increased activity in copper and other smelters contributed to the increase in output in 1937.

Limestone for agricultural use (5,004,930 tons valued at $6,454,695) increased 28 per cent in quantity and 43 per cent in value. Of the total, 766,750 tons valued at $1,067,197 was noncommercial produc-

CRUSHED AND BROKEN STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1936-37, BY PRINCIPAL USES.

Use	1936			1937		
	Short tons	Value		Short tons	Value	
		Total	Average		Total	Average
Concrete and road metal	79,336,740	$76,095,094	$0.96	80,271,900	$76,972,465	$0.96
Railroad ballast	7,934,080	6,022,693	.76	8,160,670	5,852,143	.72
Metallurgical	17,724,880	11,576,156	.65	21,331,970	14,704,458	.69
Alkali works	4,394,670	2,107,112	.48	4,860,520	2,295,599	.47
Riprap	11,318,880	8,922,761	.79	5,388,920	5,850,101	1.09
Agricultural	3,907,710	4,512,703	1.15	5,004,930	6,454,695	1.29
Refractory (ganister, mica schist, dolomite, soapstone)	1,324,040	1,831,693	1.38	1,525,260	2,258,900	1.48
Asphalt filler	210,370	498,031	2.37	351,590	686,951	1.95
Calcium carbide works	348,170	178,694	.51	472,240	266,557	.56
Sugar factories	540,470	754,967	1.40	566,620	862,660	1.52
Glass factories	265,890	429,546	1.62	274,770	460,352	1.68
Paper mills	255,880	399,861	1.56	322,810	589,091	1.83
Other uses	2,046,120	4,430,982	2.17	2,729,810	4,626,619	1.69
	129,607,900	117,760,293	.91	131,262,010	121,880,591	.93
Portland cement (including "cement rock")[1]	28,650,000	(2)	----	29,547,000	(2)	----
Natural cement ("cement rock")[3] Lime[3]	7,500,000	(2)	----	8,250,000	(2)	----
Total stone	165,757,900	----	----	169,059,010	----	----
Asphaltic stone	547,333	2,420,792	4.42	447,213	2,035,410	4.55
Slate granules and flour	289,650	1,646,780	5.69	277,010	1,578,014	5.70

[1] Value reported as cement in the chapter on cement.
[2] No value available for stone used in manufacture of cement and lime.
[3] Value reported as lime in chapter on lime.

tion by the Soil Conservation Service, WPA, and State, County, and other social agencies.

Stone used for manufacturing purpose by alkali works amounted to 4,860,520 tons valued at $2,295,599, an increase of 11 per cent in quantity. Refractory stone, used for lining and patching furnaces, amounted to 1,525,260 short tons valued at $2,258,900, 15 per cent more stone than in 1937. Of this total, 576,900 tons valued at $580,720 was dolomitic limestone, and the remainder quartzite, sandstone, soapstone, and mica schist. The output for the other products in 1937 was crushed stone for asphalt filler, 351,590 tons valued at $686,951; calcium carbide, 472,240 tons valued at $266,557; sugar factories, 566,620 tons valued at $862,660; glass factories, 274,770 tons valued at $460,352; and paper mills, 322,810 tons valued at $589,091, all of which represent increased output.

The accompanying tables show statistics of the crushed stone industry for 1937.

CRUSHED STONE SOLD OR USED BY COMMERCIAL AND NONCOMMERCIAL[1] OPERATORS IN THE UNITED STATES, 1933-37.[2]

Year	Commercial operations			Noncommercial operations[1]			Total
	Short tons	Average value per ton	Per cent of total quantity	Short tons	Average value per ton	Per cent of total quantity	Short tons
1933	37,839,200	$0.84	83.2	7,651,410	$0.95	16.8	45,490,610
1934	43,259,180	.94	71.4	17,308,740	.91	28.6	60,567,920
1935	38,090,660	.90	69.6	16,663,860	.87	30.4	54,754,520
1936	57,494,430	.93	65.9	29,776,390	.95	34.1	87,270,820
1937	62,315,350	.88	70.5	26,117,220	1.06	29.5	88,432,570

[1] By States, Counties, Municipalities, and other Government agencies, directly or under lease.
[2] Includes stone for concrete and road metal and railroad ballast.

LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES FOR MISCELLANEOUS USES, 1936-37

Use	1936		1937	
	Short tons	Value	Short tons	Value
Alkali works	4,394,670	$2,107,012	4,860,520	$2,295,599
Calcium carbide works	348,170	178,694	472,240	266,557
Coal-mine dusting	53,480	182,725	64,610	227,061
Filler (not whiting substitute)				
Asphalt	210,370	498,031	351,590	686,951
Fertilizer	38,380	78,042	74,400	174,218
Other	78,490	266,456	20,890	38,726
Filter beds	98,690	107,219	34,970	34,250
Glass factories	265,890	429,546	274,770	460,352
Magnesia works (dolomite)	126,260	211,958	96,730	158,023
Mineral food	53,830	214,631	67,230	238,847
Mineral (rock) wool	180,320	151,932	146,330	116,084
Paper mills	255,880	399,861	322,810	589,091
Poultry grit	22,820	115,604	27,360	118,343
Road base	326,490	238,406	206,060	106,931
Stucco, terrazzo, and artificial stone	52,850	175,520	36,180	152,788
Sugar factories	540,470	754,967	566,620	882,660
Whiting substitute[1]	179,110	894,913	194,080	923,494
Other[2]	263,030	138,021	173,000	328,768
Unspecified	52,070	51,576	68,780	64,875
	7,541,270	$7,195,114	8,059,170	$7,843,618

[1] Includes stone for filler for graphite, kalsomine, linoleum, paint, pigments, pottery, putty, regrinding, rubber, sealing wax, soap, tile, and uses not specified.
[2] Includes stone for acetic acid, acid neutralization, bird gravel, carbon dioxide, cement blocks, chemicals (unspecified), concrete blocks and pipes, dye works, explosives, fill, fireplace stone, foundry facings, lime burning, roofing gravel, sand, spalls, and waste rock.

The Effects of a $100,000,000 Highway Expenditure on the Economic Structure[1]

Employment

THE purpose of this statement is to show the far reaching influence of highway construction on employment and on related and unrelated industries.

The analysis of the effects of a $100,000,000 highway expenditure shown graphically on the reverse side of this sheet is based on an assumed distribution to four classes of work as follows.

Grading	$ 19,387,900
Surfacing	63,247,300
Structures	16,019,100
Miscellaneous	1,345,700
Total	$100,000,000

This expenditure results in an annual employment of 102,690 persons of which 37,960 are employed directly on the job and 64,730 are employed indirectly in industries furnishing materials, equipment, and supplies.

The average annual construction expenditure in the United States from 1926 to 1933 was $8,894,875,000 of which $1,349,177,000 or 15 percent was spent for public highways. This expenditure resulted in the employment of approximately 1,385,000 persons directly and indirectly and furnished a living for more than 4,000,000 persons annually.

Direct Distribution

Distribution of funds from the $100,000,000 highway expenditure is made to four general items, each of which receive the following percentages:

Labor	24.39	percent
Equipment	21.29	"
Materials	48.75	"
Other Expense	5.57	"
Total	100.00	"

[1] From Highway Statistical Service, Vol. No. 1, June, 1938, American Road Builders Association.

EQUIPMENT EXPENSE IS DISTRIBUTED AS FOLLOWS:

Power Shovels, Cranes, etc.	$ 4,177,800
Graders and Scrapers	986,000
Drilling Equipment	743,500
Concrete Paving Equipment	1,587,200
Bituminous	760,400
Tractors	2,061,700
Trucks	8,563,900
Other Hauling Equipment	989,000
Culvert and Bridge Equipment	632,700
Pumping Equipment	485,300
Crushing, Screening, and Conveying	301,000
Total	$21,288,500

MATERIALS EXPENSE IS DISTRIBUTED AS FOLLOWS:

Fine Aggregate	$ 4,558,200
Coarse Aggregate	14,720,200
Cement	19,502,100
Iron and Steel	5,739,200
Asphalt, Tar	2,632,800
Lumber	648,100
Brick	104,000
Pipe	843,900
Total	$48,748,500

Value of Business

In summing up the economic influence of highway construction it has been found that the $100,000,000 expenditure eventually goes entirely to labor. The expenditure distributed through the many items required in highway construction sets in motion forces which eventually result in about $315,000,000 of business. This is the result of each successive stage of processing of materials which distribute expense to labor, equipment, materials, transportation, etc.

Source of Information—"An Economic and Statistical Analysis of Highway Construction and Expenditures" by United States Bureau of Public Roads.

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